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1. A method of reducing noise in a transmitted signal comprised of a plurality of frames, each of said frames including a plurality of frequency bands; said method comprising the steps of :
  - determining a respective total signal energy and a respective current estimate of the
  - 5 noise energy for at least one of said plurality of frequency bands of at least one of said plurality of frames;
  - determining a respective local signal-to-noise ratio ( $SNR_{post}$ ) for said at least one of said plurality of frequency bands as a function of said respective signal energy and said respective current estimate of the noise energy;
  - 10 determining a respective smoothed signal-to-noise ratio ( $SNR_{prior}$ ) for said at least one of said plurality of frequency bands from said respective local signal-to-noise ratio and another respective signal-to-noise ratio ( $SNR_{est}$ ) estimated for a previous frame; and calculating a respective filter gain value for said at least one of said plurality of frequency bands from said respective smoothed signal-to-noise ratio.

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2. (Amended) The method of claim 1 wherein said respective local signal-noise ratio (SNR<sub>pos</sub>) is determined by the following relation:

$$SNR_{pos}(f) = POS\left[\frac{E_s^P(f)}{E_n^P(f)} - 1\right],$$

wherein POS[x] has the value x when x is positive and has the value 0 otherwise, [E<sub>s</sub>(f)]  
5 E<sub>s</sub><sup>P</sup>(f) is said respective a perceptual total [signal] energy value and [E<sub>n</sub>(f)] E<sub>n</sub><sup>P</sup>(f) is [said  
respective current estimate of the] a perceptual noise energy value.

3. The method of claim 1 wherein said estimated respective signal-to-noise ratio (SNR<sub>est</sub>) is determined by the following relation:

wherein  $G(f)$  is a prior respective signal gain and  $\text{SNR}_{\text{prior}}$  is said respective local signal-to-noise ratio.

4. The method of claim 1 wherein said respective smoothed signal-to-noise ratio ( $\text{SNR}_{\text{prior}}$ ) is determined by the following relation:

$$\text{SNR}_{\text{prior}}(f) = (1 - \gamma)\text{SNR}_{\text{prior}}(f) + \gamma\text{SNR}_{\text{est}}(f),$$

wherein  $\gamma$  is a smoothing constant,  $\text{SNR}_{\text{prior}}$  is said respective local signal-to-noise ratio and  $\text{SNR}_{\text{est}}$  is said estimated respective signal-to-noise ratio.

5. The method of claim 1 wherein said respective filter gain value is determined by the following relation:

$$G(f) = C \cdot \sqrt{[\text{SNR}_{\text{prior}}(f)]},$$

wherein  $\text{SNR}_{\text{prior}}$  is said respective smoothed signal-to-noise ratio.

6. The method of claim 1 further comprising the step of forming said at least one of said plurality of frames from a first number of new speech samples and a second number of prior speech samples.

7. The method of claim 1 further comprising the step of forming said plurality of frequency bands by carrying out a fast Fourier transform (FFT) on said at least one of said plurality of frames.

8. The method of claim 1 further comprising the steps of :  
determining whether said at least one of said plurality of frames is a non-speech frame;

updating, when said at least one of said plurality of frames is a non-speech frame, sa

5 current estimate of the noise energy level of said at least one of said plurality of bands of said at least one of said plurality of frames; and

determining said respective filter gain value as a function of said updated current estimate of the noise energy level.

9. The method of claim 8 wherein said at least one of said plurality of frames is determined to be a non-speech frame when said at least one frame is a stationary frame.

10. The method of claim 9 wherein said at least one of said plurality of frames is determined to be a stationary frame when a difference in a logarithm of an energy of said at least one frame and a logarithm in an energy of at a prior one of said plurality of frames exceeds a predefined threshold value.

10. (Amended) The method of claim 9 wherein said at least one of

said plurality of frames is determined to be a stationary frame when a difference in a logarithm of an energy of said at least one frame and a logarithm in an energy of at a prior one of said plurality of frames is less than [exceeds] a first predefined threshold value and :  
5      linear predictive coding (LPC) prediction error exceeds a second predefined threshold value

11. (Amended) The method of claim 8 wherein said at least one of said plurality of frames is determined to be a non-speech frame as a function of a sum of weight values, each of said weighted values corresponding to a respective one of said frequency bands of said respective one of said plurality of frames, each of said weighted values being  
5      product of a logarithm of a speech likelihood metric of said corresponding one of said frequency bands and a weighting factor of said corresponding one of said frequency bands, and [as a function of] when a linear predictive coding (LPC) prediction error exceeds a second predefined threshold value.

12. The method of claim 11 wherein said speech likelihood metric of said corresponding one of said frequency bands is determined by the following relation:

$$\Lambda(f) = \frac{e^{\left[ \frac{\text{SNR}_{\text{prior}}(f)}{1 + \text{SNR}_{\text{prior}}(f)} \right] \text{SNR}_{\text{post}}(f)}}{1 + \text{SNR}_{\text{prior}}(f)}, \text{ wherein } \text{SNR}_{\text{post}} \text{ is said respective local signal-to-noise ratio and } \text{SNR}_{\text{prior}} \text{ is said respective smoothed signal-to-noise ratio.}$$

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to-noise ratio and  $\text{SNR}_{\text{prior}}$  is said respective smoothed signal-to-noise ratio.

13. (Amended) The method of claim 8 wherein said at least a respective one  
said plurality of frames is determined to be a non-speech frame as a function of a normalize  
skewness value of a linear predictive coding (LPC) residual of said at least a respective one  
said plurality of frames and [as a function of] when a linear predictive coding (LPC)  
5 prediction error exceeds a second redefined threshold value.

14. The method of claim 13 wherein said skewness value of said LPC residual is  
determined by the following relation:

$$SK = \frac{1}{N} \sum_{n=0}^{N-1} [e(n)]^3, \text{ wherein } e(n) \text{ are sampled values of an LPC residual, and } N \text{ is a frame}$$

length.

15. (Amended) The method of claim 14 wherein said skewness value is  
normalized by a function of an estimated value of a total energy E, of said respective  
said plurality of frames, said total energy E, being determined by the following relation

$$E_x = \frac{1}{N} \sum_{n=0}^{N-1} [e(n)]^2, \text{ wherein } e(n) \text{ are sampled values of an LPC residual, and } N \text{ is a frame}$$

5 length.

16. (Amended) The method of claim 14 wherein said skewness value is normalized by a function of an estimated value of a variance of said skewness value, said variance being determined by the following relation:

$$Var[SK] = \frac{15E^3}{N}, \text{ wherein } E_n \text{ is said current estimate of the noise energy level and } N \text{ is}$$

5 frame length.

17. The method of claim 8 wherein said current estimate of the noise energy level is determined by the following relation:

$$E(m+1, f) = (1 - \alpha)E(m, f) + \alpha E_{ch}(m, f), \text{ wherein } E(m, f) \text{ is a prior estimated noise energy level, } E_{ch}(m, f) \text{ is a band energy, } m \text{ is an iteration index and } \alpha \text{ is an update constant.}$$

18. (Amended) The method of claim 17 wherein a value of said update criteria is determined by one of a watchdog timer being expired, said at least one of said plurality of frames being stationary, said at least one of said plurality of frames being a non-speech frame, a LPC residual of said at least one of said plurality of frames having substantially zero skewness, [and] a current value of said estimated noise energy level being greater than energy of said plurality of frames and a linear predictive coding (LPC) predicting error exceeding a predefined threshold value.

19. (Amended) The method of claim 17 wherein said estimated noise level is forced to be updated [using a noise energy level of a current frame] when said estimate

level is not updated within a preset interval.

20. The method of claim 1 wherein said filtering gain is further adjusted as a function of an aggressiveness setting parameter ( $F$ ) according to the following relation:

$$G'(f) = \sqrt{[1 - F \cdot (1 - G(f))]} , \text{ wherein } G(f) \text{ is said filtering gain prior to being adjusted.}$$

21. The method of claim 1 further comprising the steps of: determining a respective speech likelihood metric of each of said plurality of said frequency bands of said at least one of said plurality of frames; determining a number of said plurality of said frequency bands having said respective speech likelihood metric above a threshold value; and setting, 5 when said number exceeds a predetermined percentage of a total number of said plurality of

said frequency bands, said filter gain for each of said plurality of said frequency bands minimum value.

22. The method of claim 11 wherein an said filtering gain is set to a minimum value when said speech likelihood metric is less than a threshold value.

23. A method of reducing noise in a transmitted signal comprised of a plurality of frames, each of said frames including a plurality of frequency bands; said method comprising the steps of :

determining whether at least a respective one of said plurality of frames is a non-speech frame;

estimating, when said at least one of said plurality of frames is a non-speech frame, a noise energy level of at least one of said plurality of bands of said at least a respective one of said plurality of frames; and

filtering said at least one band as a function of said estimated noise level.

24. The method of claim 23 wherein said at least a respective one of said plurality of frames is determined to be a non-speech frame when said at least one frame is a static frame.

25. (Amended) The method of claim 24 wherein said at least a respective one of said plurality of frames is determined to be a stationary frame when a difference in a logarithm of an energy of said at least one frame and a logarithm in an energy of at a prior one of said plurality of frames is less than [exceeds] a first predefined threshold value and a linear predictive coding (LPC) prediction error exceeds a second predefined threshold value.

26. (Amended) The method of claim 23 wherein said at least a respective one of said plurality of frames is determined to be a non-speech frame as a function of a sum of weighted values, each of said weighted values corresponding to a respective one of said frequency bands of said respective one of said plurality of frames, each of said weighted values being a product of a logarithm of a speech likelihood metric of said corresponding one of said frequency bands and a weighting factor of said corresponding one of said frequency bands, and [as a function of] when a linear predictive coding (LPC) prediction error exceeds a second predefined threshold value.

27. The method of claim 26 wherein said speech likelihood metric of said corresponding one of said frequency bands is determined by the following relation:

$$\Lambda(f) = \frac{e^{\left[ \frac{SNR_{prior}(f)}{1 + SNR_{prior}(f)} \right]}}{1 + SNR_{prior}(f)}, \text{ wherein } SNR_{post} \text{ is said respective local signal-to-noise ratio, where } SNR_{prior} \text{ is said smoothed signal-to-noise ratio.}$$

to-noise ratio and  $SNR_{prior}$  is said respective smoothed signal-to-noise ratio.

28. (Amended) The method of claim 23 wherein said at least a respective one of said plurality of frames is determined to be a non-speech frame as a function of a normalized skewness value of a linear predictive coding (LPC) residual of said at least a respective one of said plurality of frames and [as a function] when of a linear predictive coding (LPC) prediction error exceeds a second predefined threshold value.

29. The method of claim 28 wherein said skewness value of said LPC residual is determined by the following relation:

$$SK = \frac{1}{N} \sum_{n=0}^{N-1} [e(n)]^3, \text{ wherein } e(n) \text{ are sampled values of an LPC residual, and } N \text{ is a frame}$$

length.

30. (Amended) The method of claim 29 wherein said skewness value is normalized by a function of an estimated value of a total energy  $E_t$  of said respective one of said plurality of frames, said total energy  $E_t$  being determined by the following relation:

$$E_x = \frac{1}{N} \sum_{n=0}^{N-1} [e(n)]^2, \text{ wherein } e(n) \text{ are sampled values of an LPC residual, and } N \text{ is a frame}$$

5 length.

31. (Amended) The method of claim 29 wherein said skewness value is normalized by a function of an estimated value of a variance of said skewness value, said variance being determined by the following relation:

$$Var[SK] = \frac{15E^3}{N}, \text{ wherein } E_n \text{ is said current estimate of the noise energy level and } N \text{ is a}$$

5 frame length.

32. The method of claim 23 wherein said estimated noise level is determined by the following relation:

$$E(m+1, f) = (1 - \alpha)E(m, f) + \alpha E_{ch}(m, f), \text{ wherein } E(m, f) \text{ is a prior estimated noise energy level, } E_{ch}(m, f) \text{ is a band energy, } m \text{ is an iteration index and } \alpha \text{ is an update constant.}$$

33. (Amended) The method of claim 32 wherein a value of said update constant  $\alpha$  is determined by one of a watchdog timer being expired, said at least one of said plurality of frames being stationary, said at least one of said plurality of frames being a non-speech frame, a LPC residual of said at least one of said plurality of frames having substantially zero skewness, [and] a current value of said estimated noise energy level being greater than a total energy of said plurality of frames and a linear predictive coding (LPC) prediction error exceeding a predefined threshold value.

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34. An apparatus of reducing noise in a transmitted signal including a plurality of frames, each of said frames including a plurality of frequency bands; said apparatus comprising:

means for determining a respective total signal energy and a respective current estimate of the noise energy for at least one of said plurality of frequency bands of at least one of said plurality of frames;

means for determining a respective local signal-to-noise ratio ( $\text{SNR}_{\text{local}}$ ) for said at least one of said plurality of frequency bands as a function of said respective signal energy and said respective current estimate of the noise energy;

means for determining a respective smoothed signal-to-noise ratio ( $\text{SNR}_{\text{smoothed}}$ ) for said at least one of said plurality of frequency bands from said respective local signal-to-noise ratio and another respective signal-to-noise ratio ( $\text{SNR}_{\text{prev}}$ ) estimated for a previous frame; and

means for calculating a respective filter gain value for said at least one of said plurality of frequency bands from said respective smoothed signal-to-noise ratio.

35. (Amended) The apparatus of claim 34 wherein said respective local signal-to-noise ratio ( $\text{SNR}_{\text{per}}$ ) is determined by the following relation:

$$\text{SNR}_{\text{per}}(f) = \text{POS} \left[ \frac{E_r(f)}{E_n^P(f)} - 1 \right],$$

wherein  $\text{POS}[x]$  has the value  $x$  when  $x$  is positive and has the value 0 otherwise, [ $E_s(f)$ ]

5  $E_r(f)$  is [said respective] a perceptual total [signal] energy value and [ $E_s(f)$ ]  $E_n^P(f)$  is [said respective current estimate of the] a perceptual noise energy value.

36. The apparatus of claim 34 wherein said estimated respective signal-to-noise ratio ( $\text{SNR}_{\text{est}}$ ) is determined by the following relation:

$$SNR_{est}(f) = |G(f)|^2 \cdot SNR_{pos}(f)$$

wherein  $G(f)$  is a prior respective signal gain and  $SNR_{pos}$  is said respective local signal-to-noise ratio.

37. The apparatus of claim 34 wherein said respective smoothed signal-to-noise ratio ( $SNR_{prior}$ ) is determined by the following relation:

$$SNR_{prior}(f) = (1 - \gamma)SNR_{pos}(f) + \gamma SNR_{est}(f),$$

wherein  $\gamma$  is a smoothing constant,  $SNR_{pos}$  is said respective local signal-to-noise ratio and  $SNR_{est}$  is said estimated respective signal-to-noise ratio.

38. The apparatus of claim 34 wherein said respective filter gain value is determined by the following relation:

$$G(f) = C \cdot \sqrt{[SNR_{prior}(f)]},$$

wherein  $SNR_{prior}$  is said respective smoothed signal-to-noise ratio.

39. The apparatus of claim 34 further comprising the means for forming said at least one of said plurality of frames from a first number of new speech samples and a second number of prior speech samples.

40. The apparatus of claim 34 further comprising means for forming said plurality of frequency bands by carrying out a fast Fourier transform (FFT) on said at least one of said plurality of frames.

41. The apparatus of claim 34 further comprising:  
means for determining whether said at least one of said plurality of frames is a non-speech frame;  
means for updating, when said at least one of said plurality of frames is a non-speech

5 frame, said current estimate of the noise energy level of said at least one of said plurality of bands of said at least one of said plurality of frames; and

means for determining said respective filter gain value as a function of said updated current estimate of the noise energy level.

42. The apparatus of claim 41 wherein said at least one of said plurality of frames is determined to be a non-speech frame when said at least one frame is a stationary frame.



43. (Amended) The apparatus of claim 42 wherein said at least one of said plurality of frames is determined to be a stationary frame when a difference in a logarithm of an energy of said at least one frame and a logarithm in an energy of at a prior one of said plurality of frames [exceeds] is less than a first predefined threshold value and a 5 linear predictive coding (LPC) prediction error exceeds a second predefined threshold value.

44. (Amended) The apparatus of claim 42 wherein said at least one of said plurality of frames is determined to be a non-speech frame as a function of a sum of weighted value, each of said weighted values corresponding to a respective one of said frequency band of said respective one of said plurality of frames, each of said weighted values being a 5 product of a logarithm of a speech likelihood metric of said corresponding one of said frequency bands and a weighting factor of said corresponding one of said frequency bands, and [as a function of] when a linear predictive coding (LPC) prediction error exceeds a second predefined threshold value.

45. The apparatus of claim 44 wherein said speech likelihood metric of said corresponding one of said frequency bands is determined by the following relation:

$$\Lambda(f) = \frac{e^{\left[ \frac{SNR_{prior}(f)}{1+SNR_{prior}(f)} \cdot SNR_{post}(f) \right]}}{1+SNR_{prior}(f)}, \text{ wherein } SNR_{post} \text{ is said respective local signal-}$$

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46. (Amended) The apparatus of claim 41 wherein said at least a respective one of said plurality of frames is determined to be a non-speech frame as a function of a normalized skewness value of a linear predictive coding (LPC) residual of said at least a respective one of said plurality of frames and [as a function of] when a linear predictive coding (LPC) prediction error exceeds a second predefined threshold value.

47. The apparatus of claim 46 wherein said skewness value of said LPC residual is determined by the following relation:

$$SK = \frac{1}{N} \sum_{n=0}^{N-1} [e(n)]^5, \text{ wherein } e(n) \text{ are sampled values of an LPC residual, and } N \text{ is a frame}$$

length.

48. (Amended) The apparatus of claim 47 wherein said skewness normalized by an estimated value of a total energy  $E_x$  of said respective one of frames, said total energy  $E_x$  being determined by the following relation:

$$E_x = \frac{1}{N} \sum_{n=0}^{N-1} [e(n)]^2, \text{ wherein } e(n) \text{ are sampled values of an LPC residual, :}$$

5 frame length.

49. (Amended) The apparatus of claim 47 wherein said skewness normalized by a function of an estimated value of a variance of said skewness: variance being determined by the following relation:

$$Var[SK] = \frac{15E^3}{N}, \text{ wherein } E_n \text{ is said current estimate of the noise energy}$$

5 frame length.

50. The apparatus of claim 41 wherein said estimated noise level is determined by the following relation:

$$E(m+1, f) = (1 - \alpha)E(m, f) + \alpha E_{ch}(m, f), \text{ wherein } E(m, f) \text{ is a prior estimated noise energy level, } E_{ch}(m, f) \text{ is a band energy, } m \text{ is an iteration index and } \alpha \text{ is an update constant.}$$

51. (Amended) The apparatus of claim 50 wherein a value of said update constant  $\alpha$  is determined by one of a watchdog timer being expired, said at least one of said plurality of frames being stationary, said at least one of said plurality of frames being a non-speech frame, a LPC residual of said at least one of said plurality of frames having substantially zero skewness, [and] a current value of said estimated noise energy level being greater than a total energy of said plurality of frames and a linear predictive coding (LPC) prediction error exceeding a predefined threshold value.

52. (Amended) The apparatus of claim 41 wherein said estimated noise level is forced to be updated [using a noise energy level of a current frame] when said estimated noise level is not updated within a preset interval.

53.

The apparatus of claim 34 wherin said filtering gain is further adjusted as a function of an aggressiveness setting parameter ( $F$ ) according to the following relation:

$$G'(f) = \sqrt{[1 - F \cdot (1 - G(f)^2)]} , \text{ wherein } G(f) \text{ is said filtering gain prior to being adjusted}$$

54. The apparatus of claim 34 further comprising the steps of: determining a respective speech likelihood metric of each of said plurality of said frequency bands of said at least one of said plurality of frames; determining a number of said plurality of said frequency bands having said respective speech likelihood metric above a threshold value; and setting, when said number exceeds a predetermined percentage of a total number of said plurality of

said frequency bands, said filter gain for each of said plurality of said frequency bands to a minimum value.

55. The apparatus of claim 44 wherein said filtering gain is set to a minimum value when said speech likelihood metric is less than a threshold value.

56. An apparatus of reducing noise in a transmitted signal including a plurality of frames, each of said frames including a plurality of frequency bands; said apparatus comprising the steps of :

means for determining whether at least a respective one of said plurality of frames is a  
5 non-speech frame;

means for estimating, when said at least one of said plurality of frames is a non-speech frame, a noise energy level of at least one of said plurality of bands of said at least a respective one of said plurality of frames; and

means for filtering said at least one band as a function of said estimated noise level.

57. The apparatus of claim 56 wherein said at least a respective one of said plurality of frames is determined to be a non-speech frame when said at least one frame is a stationary frame.

58. (Amended) The apparatus of claim 57 wherein said at least a respective  
of said plurality of frames is determined to be a stationary frame when a difference in a  
logarithm of an energy of said at least one frame and a logarithm in an energy of at a prior  
one of said plurality of frames [exceeds] is less than a first predefined threshold value and  
5 linear predictive coding (LPC) prediction error exceeds a second predefined threshold val

59. (Amended) The apparatus of claim 56 wherein said at least a respective  
of said plurality of frames is determined to be a non-speech frame as a function of a sum of  
weighted values, each of said weighted values corresponding to a respective one of said  
frequency bands of said respective one of said plurality of frames, each of said weighted  
5 values being a product of a logarithm of a speech likelihood metric of said corresponding

of said frequency bands and a weighting factor of said corresponding one of said frequency  
bands, and when [as a function of] a linear predictive coding (LPC) prediction error exceeds  
second predefined threshold value.

60. The apparatus of claim 59 wherein said speech likelihood metric of said  
corresponding one of said frequency bands is determined by the following relation:

$$\Lambda(f) = \frac{e^{\left[ \left( \frac{SNR_{prior}(f)}{1 + SNR_{prior}(f)} \right) SNR_{post}(f) \right]}}{1 + SNR_{prior}(f)}, \text{ wherein } SNR_{post} \text{ is said respective local signal-}$$

to-noise ratio and  $SNR_{prior}$  is said respective smoothed signal-to-noise ratio.

61. (Amended) The apparatus of claim 56 wherein said at least a respective  
of said plurality of frames is determined to be a non-speech frame as a function of a  
normalized skewness value of a linear predictive coding (LPC) residual of said at least a  
respective one of said plurality of frames and [as a function of] when a linear predictive  
5 coding (LPC) prediction error exceeds a second predefined threshold value.

62. The apparatus of claim 61 wherein said skewness value of said LPC residual is  
determined by the following relation:

$$SK = \frac{1}{N} \sum_{n=0}^{N-1} [e(n)]^3, \text{ wherein } e(n) \text{ are sampled values of an LPC residual, and } N \text{ is a frame}$$

length.

63. (Amended) The apparatus of claim 61 wherein said skewness value is normalized by an estimated value of a total energy  $E_x$  of said respective one of said plural frames, said total energy  $E_x$  being determined by the following relation:

$$E_x = \frac{1}{N} \sum_{n=0}^{N-1} [e(n)]^2, \text{ wherein } e(n) \text{ are sampled values of an LPC residual, and } N \text{ is a frame length.}$$

5 frame length.

64. (Amended) The apparatus of claim 62 wherein said skewness value is normalized by a function of an estimated value of a variance of said skewness value, said variance being determined by the following relation:

$$Var[SK] = \frac{15E^3}{N}, \text{ wherein } E_n \text{ is said current estimate of the noise energy level and } N$$



5 frame length.

65. The apparatus of claim 56 wherein said estimated noise level is determined by the following relation:

$E(m+1, f) = (1 - \alpha)E(m, f) + \alpha E_{bh}(m, f)$ , wherein  $E(m, f)$  is a prior estimated noise energy level,  $E_{bh}(m, f)$  is a band energy,  $m$  is an iteration index and  $\alpha$  is an update constant.

66. (Amended) The apparatus of claim 65 wherein a value of said update constant  $\alpha$  is determined by one of a watchdog timer being expired, said at least one of said plurality of frames being stationary, said at least one of said plurality of frames being a non-speech frame, a LPC residual of said at least one of said plurality of frames having substantially zero skewness, [and] a current value of said estimated noise energy level being greater than a total energy of said plurality of frames and a linear predictive coding (LPC) prediction error exceeding a predefined threshold value.

Add the following new claims:

--67. The method of claim 10 wherein said LPC prediction error (PE) is determined by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analysis.}$$

68. The method of claim 11 wherein said LPC prediction error (PE) is determined by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analysis.}$$

69. The method of claim 13 wherein said LPC prediction error (PE) is determined by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analy.}$$

70. The method of claim 18 wherein said LPC prediction error (PE) is determined by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analy.}$$

71. The method of claim 25 wherein said LPC prediction error (PE) is determined by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analy.}$$

72. The method of claim 26 wherein said LPC prediction error (PE) is determined by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analy.}$$

73. The method of claim 28 wherein said LPC prediction error (PE) is determined by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analy.}$$

74. The method of claim 33 wherein said LPC prediction error (PE) is determined

9 by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analysis.}$$

75. The of claim 43 wherein said LPC prediction error (PE) is determined by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analysis.}$$

76. The of claim 44 wherein said LPC prediction error (PE) is determined by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analysis.}$$

77. The of claim 46 wherein said LPC prediction error (PE) is determined by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analysis.}$$

78. The of claim 51 wherein said LPC prediction error (PE) is determined by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analysis.}$$

79. The method of claim 58 wherein said LPC prediction error (PE) is determined by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analysis.}$$

80. The method of claim 59 wherein said LPC prediction error (PE) is determined by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analysis.}$$

81. The method of claim 61 wherein said LPC prediction error (PE) is determined by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analysis.}$$

82. The method of claim 66 wherein said LPC prediction error (PE) is determined by the following relation:

$$PE = \prod_{k=0}^{K-1} [1 - r_{ck}^{-2}], \text{ wherein } r_{ck} \text{ is a reflection coefficient generated by LPC analysis.}$$

83. The method of claim 15 wherein said normalized skewness value  $\gamma_3$  is determined by the following relation:

$$\gamma_3 = \frac{SK}{E_x^{15}}$$



84. The method of claim 16 wherein said normalized skewness value  $\gamma_3'$  is determined by the following relation:

$$\gamma_3' = \frac{SK}{\sqrt{\frac{15E_n^3}{N}}}.$$

85. The method of claim 30 wherein said normalized skewness value  $\gamma_3$  is determined by the following relation:

$$\gamma_3 = \frac{SK}{E_x^{15}}.$$

86. The method of claim 31 wherein said normalized skewness value  $\gamma_3'$  is determined by the following relation:

$$\gamma_3' = \frac{SK}{\sqrt{\frac{15E_n^3}{N}}}.$$

87. The of claim 48 wherein said normalized skewness value  $\gamma_3$  is determined by the following relation:

$$\gamma_3 = \frac{SK}{E_x^{15}}.$$

88. The of claim 49 wherein said normalized skewness value  $\gamma_3'$  is determined by the following relation:

$$\gamma_3' = \frac{SK}{\sqrt{\frac{15E_n^3}{N}}}.$$

89. The of claim 63 wherein said normalized skewness value  $\gamma_3'$  is determined by the following relation:

$$\gamma_3' = \frac{SK}{E_x^{1.5}}$$

90. The of claim 64 wherein said normalized skewness value  $\gamma_3'$  is determined by the following relation:

$$\gamma_3' = \frac{SK}{\sqrt{\frac{15E_n^3}{N}}}.$$

91. The method of claim 17 wherein said update constant  $\alpha$  has a value of 0.002 when a watchdog timer is expired and a linear predictive coding (LPC) prediction error (PE) exceeds a predefined LPC prediction error threshold value  $T_{PE1}$ ; said update constant  $\alpha$  has a value of 0.05 when said at least one of said plurality of frames is stationary; said update constant  $\alpha$  has a value of 0.1 when a noise likelihood value is less than a noise likelihood threshold value  $T_{LIK}$  and said LPC prediction error PE is greater than a predefined LPC prediction error threshold value  $T_{PE2}$  such that said at least one of said plurality of frames is a non-speech frame; said update constant  $\alpha$  has a value of 0.05 when an absolute value of a

normalized skewness of a LPC residual is less than a first threshold value  $T_a$ , said ske  
10 of said LPC residual being normalized by total energy, or is less than a second thresh-  
value  $T_b$ , said skewness of said LPC residual being normalized by a variance of said s-  
of said LPC residual, and when said LPC prediction error PE is greater than a predefin-  
prediction error threshold value  $T_{PE1}$  so that a LPC residual of said at least one of said  
plurality of frames has substantially zero skewness; and said update constant  $\alpha$  has a v-  
15 0.1 when a current value of said estimated noise energy level is greater than a total en-  
said plurality of frames.

92. The method of claim 32 wherein said update constant  $\alpha$  has a value of  
when a watchdog timer is expired and a linear predictive coding (LPC) prediction err-  
exceeds a predefined LPC prediction error threshold value  $T_{PE1}$ ; said update constant  
value of 0.05 when said at least one of said plurality of frames is stationary; said upda-  
5 constant  $\alpha$  has a value of 0.1 when a noise likelihood value is less than a noise likeli-  
threshold value  $T_{LIK}$  and said LPC prediction error PE is greater than a predefined LP-  
prediction error threshold value  $T_{PE2}$  such that said at least one of said plurality of fra-  
non-speech frame; said update constant  $\alpha$  has a value of 0.05 when an absolute value  
normalized skewness of a LPC residual is less than a first threshold value  $T_a$ , said ske-  
10 of said LPC residual being normalized by total energy, or is less than a second thresh-  
value  $T_b$ , said skewness of said LPC residual being normalized by a variance of said s-  
of said LPC residual, and when said LPC prediction error PE is greater than a predefin-  
prediction error threshold value  $T_{PE2}$  so that a LPC residual of said at least one of said  
plurality of frames has substantially zero skewness; and said update constant  $\alpha$  has a v-

15 0.1 when a current value of said estimated noise energy level is greater than a total energy of said plurality of frames.

93. The of claim 50 wherein said update constant  $\alpha$  has a value of 0.002 when a watchdog timer is expired and a linear predictive coding (LPC) prediction error (PE) exceeds a predefined LPC prediction error threshold value  $T_{PE1}$ ; said update constant  $\alpha$  has a value of 0.05 when said at least one of said plurality of frames is stationary; said update constant  $\alpha$  has a value of 0.1 when a noise likelihood value is less than a noise likelihood threshold value  $T_{LIK}$  and said LPC prediction error PE is greater than a predefined LPC prediction error threshold value  $T_{PE2}$  such that said at least one of said plurality of frames is a non-speech frame; said update constant  $\alpha$  has a value of 0.05 when an absolute value of a normalized skewness of a LPC residual is less than a first threshold value  $T_a$ , said skewness of said LPC residual being normalized by total energy, or is less than a second threshold value  $T_b$ , said skewness of said LPC residual being normalized by a variance of said skewness of said LPC residual, and when said LPC prediction error PE is greater than a predefined LPC prediction error threshold value  $T_{PE2}$  so that a LPC residual of said at least one of said plurality of frame has substantially zero skewness; and said update constant  $\alpha$  has a value of 0.1 when a current value of said estimated noise energy level is greater than a total energy of said plurality of frames.

94. The of claim 65 wherein said update constant  $\alpha$  has a value of 0.002 when a watchdog timer is expired and a linear predictive coding (LPC) prediction error (PE) exceeds a predefined LPC prediction error threshold value  $T_{PE1}$ ; said update constant  $\alpha$  has a value of

0.05 when said at least one of said plurality of frames is stationary; said update constant  $\alpha$  has  
5 a value of 0.1 when a noise likelihood value is less than a noise likelihood threshold value  
 $T_{LIK}$  and said LPC prediction error PE is greater than a predefined LPC prediction error  
threshold value  $T_{PE2}$  such that said at least one of said plurality of frames is a non-speech  
frame; said update constant  $\alpha$  has a value of 0.05 when an absolute value of a normalized  
skewness of a LPC residual is less than a first threshold value  $T_a$ , said skewness of said LPC  
10 residual being normalized by total energy, or is less than a second threshold value  $T_b$ , said  
skewness of said LPC residual being normalized by a variance of said skewness of said LPC  
residual, and when said LPC prediction error PE is greater than a predefined LPC prediction  
error threshold value  $T_{PE2}$  so that a LPC residual of said at least one of said plurality of frames  
has substantially zero skewness; and said update constant  $\alpha$  has a value of 0.1 when a current  
15 value of said estimated noise energy level is greater than a total energy of said plurality of  
frames.

95. The method of claim 2 wherein said perceptual total energy value  $E_p^r(f)$  is  
determined by the following relation:

$E_p^r(f) = W(f) \otimes E_s(f)$ , and said perceptual noise energy  $E_p^n(f)$  is determined by the

following relation:

5  $E_p^n(f) = W(f) \otimes E_n(f)$ , wherein  $E_s(f)$  is said respective total signal energy and  $E_n(f)$   
said respective current estimate of the noise energy,  $\otimes$  denotes convolution and  $W(f)$  is an  
auditory filter centered at f.

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96. The apparatus of claim 35 wherein said perceptual total energy value  $E^P$  determined by the following relation:

$E_s^P(f) = W(f) \otimes E_s(f)$ , and said perceptual noise energy  $E_n^P(f)$  is determined by the

following relation:

5     $E_n^P(f) = W(f) \otimes E_n(f)$ , wherein  $E_n(f)$  is said respective total signal energy and said respective current estimate of the noise energy,  $\otimes$  denotes convolution and  $W(f)$  is auditory filter centered at  $f$ .

97. A method of reducing noise in a transmitted signal comprised of a plurality of frames, each of said frames including a plurality of frequency bands; said method comprising the steps of :

determining whether said plurality of frequency bands of at least a respective one of said plurality of frames are strong speech bands; and  
5    setting, when a count of said strong speech bands is less than a predetermined fraction of a total number of said plurality of frequency bands, a filter gain of at least said strong speech bands to a minimum value.

99. The method of claim 98 wherein said determining step includes determining whether said plurality of frequency bands of said respective one of said plurality of frames each has a likelihood metric whose value is greater than a predetermined threshold value.

100. The method of claim 99 wherein said speech likelihood metric of a respective

one of said plurality of frequency bands is determined by the following relation:

$$\Lambda(f) = \frac{e^{\left[ \frac{SNR_{prior}(f)}{1 + SNR_{prior}(f)} \right] SNR_{post}(f)}}{1 + SNR_{prior}(f)}, \text{ wherein } SNR_{post} \text{ is a respective local signal-to-noise ratio}$$

noise ratio and  $SNR_{prior}$  is a respective smoothed signal-to-noise ratio.

101. The method of claim 100 wherein said respective local signal-to-noise ratio ( $SNR_{post}$ ) is determined by the following relation:

$$SNR_{post}(f) = POS\left[ \frac{E_x^P(f)}{E_n^P(f)} - 1 \right], \text{ wherein } POS[x] \text{ has the value } x \text{ when } x \text{ is positive and}$$

has the value 0 otherwise,  $E_x^P(f)$  is a perceptual total energy and  $E_n^P(f)$  is a perceptual noise energy.

102. The method of claim 101 wherein said perceptual total energy value  $E_x^P(f)$  is determined by the following relation:

$$E_x^P(f) = W(f) \otimes E_s(f), \text{ and said perceptual noise energy } E_n^P(f) \text{ is determined by the}$$

following relation:

5       $E_n^P(f) = W(f) \otimes E_n(f)$ , wherein  $E_s(f)$  is a respective total signal energy and  $E_n(f)$  is

respective current estimate of the noise energy,  $\otimes$  denotes convolution and  $W(f)$  is an audi filter centered at  $f$ .

103. The method of claim 100 wherein said respective smoothed signal-to-noise ratio ( $SNR_{prior}$ ) is determined by the following relation:

$$SNR_{prior}(f) = (1 - \gamma)SNR_{past}(f) + \gamma SNR_{est}(f),$$

wherein  $\gamma$  is a smoothing constant,  $SNR_{past}$  is said respective local signal-to-noise ratio and  
5  $SNR_{est}$  is said estimated respective signal-to-noise ratio.

104. The method of claim 103 wherein said estimated respective signal-to-noise ratio ( $SNR_{est}$ ) is determined by the following relation:

$$SNR_{est}(f) = |G(f)|^2 \cdot SNR_{past}(f) , \text{ wherein } G(f) \text{ is a prior respective signal gain and} \\ SNR_{past} \text{ is said respective local signal-to-noise ratio.}$$

105. An apparatus of reducing noise in a transmitted signal comprised of a plura of frames, each of said frames including a plurality of frequency bands; said apparatus comprising:

means for determining whether said plurality of frequency bands of at least a  
5 respective one of said plurality of frames are strong speech bands; and  
means for setting, when a count of said strong speech bands is less than a  
predetermined fraction of a total number of said plurality of frequency bands, a filter gain  
at least said strong speech bands to a minium value.

106. The apparatus of claim 105 wherein said means for determining includes means for determining whether said plurality of frequency bands of said respective one of said plurality of frames each has a likelihood metric whose value is greater than a predetermined threshold value.

107. The apparatus of claim 106 wherein said speech likelihood metric of a respective one of said plurality of frequency bands is determined by the following relation:

$$\Lambda(f) = \frac{e^{\left[ \frac{SNR_{prior}(f)}{1 + SNR_{prior}(f)} \right] SNR_{post}(f)}}{1 + SNR_{prior}(f)}, \text{ wherein } SNR_{post} \text{ is a respective local signal-to-noise ratio and } SNR_{prior} \text{ is a respective smoothed signal-to-noise ratio.}$$

5 108. The apparatus of claim 107 wherein said respective local signal-to-noise ratio ( $SNR_{post}$ ) is determined by the following relation:

$$SNR_{post}(f) = POS\left[ \frac{E_s^p(f)}{E_n^p(f)} - 1 \right], \text{ wherein } POS[x] \text{ has the value } x \text{ when } x \text{ is positive and}$$

has the value 0 otherwise,  $E_s^p(f)$  is a perceptual total energy and  $E_n^p(f)$  is a perceptual noise energy.

109. The apparatus of claim 108 wherein said perceptual total energy value  $E_p^p(f)$  is determined by the following relation:

$E_p^p(f) = W(f) \otimes E_s(f)$ , and said perceptual noise energy  $E_p^p(f)$  is determined by the

following relation:

5     $E_p^p(f) = W(f) \otimes E_n(f)$ , wherein  $E_s(f)$  is a respective total signal energy and  $E_n(f)$  is a respective current estimate of the noise energy,  $\otimes$  denotes convolution and  $W(f)$  is an audio filter centered at  $f$ .

110. The apparatus of claim 107 wherein said respective smoothed signal-to-noise ratio ( $SNR_{prior}(f)$ ) is determined by the following relation:

$$SNR_{prior}(f) = (1 - \gamma) SNR_{post}(f) + \gamma SNR_{est}(f),$$

wherein  $\gamma$  is a smoothing constant,  $SNR_{post}$  is said respective local signal-to-noise ratio and

5     $SNR_{est}$  is said estimated respective signal-to-noise ratio.

111. The apparatus of claim 110 wherein said estimated respective signal-to-noise ratio ( $SNR_{est}(f)$ ) is determined by the following relation:

$$SNR_{est}(f) = |G(f)|^2 \cdot SNR_{post}(f) , \text{ wherein } G(f) \text{ is a prior respective signal gain and}$$

$SNR_{post}$  is said respective local signal-to-noise ratio.--

IN THE ABSTRACT OF THE DISCLOSURE